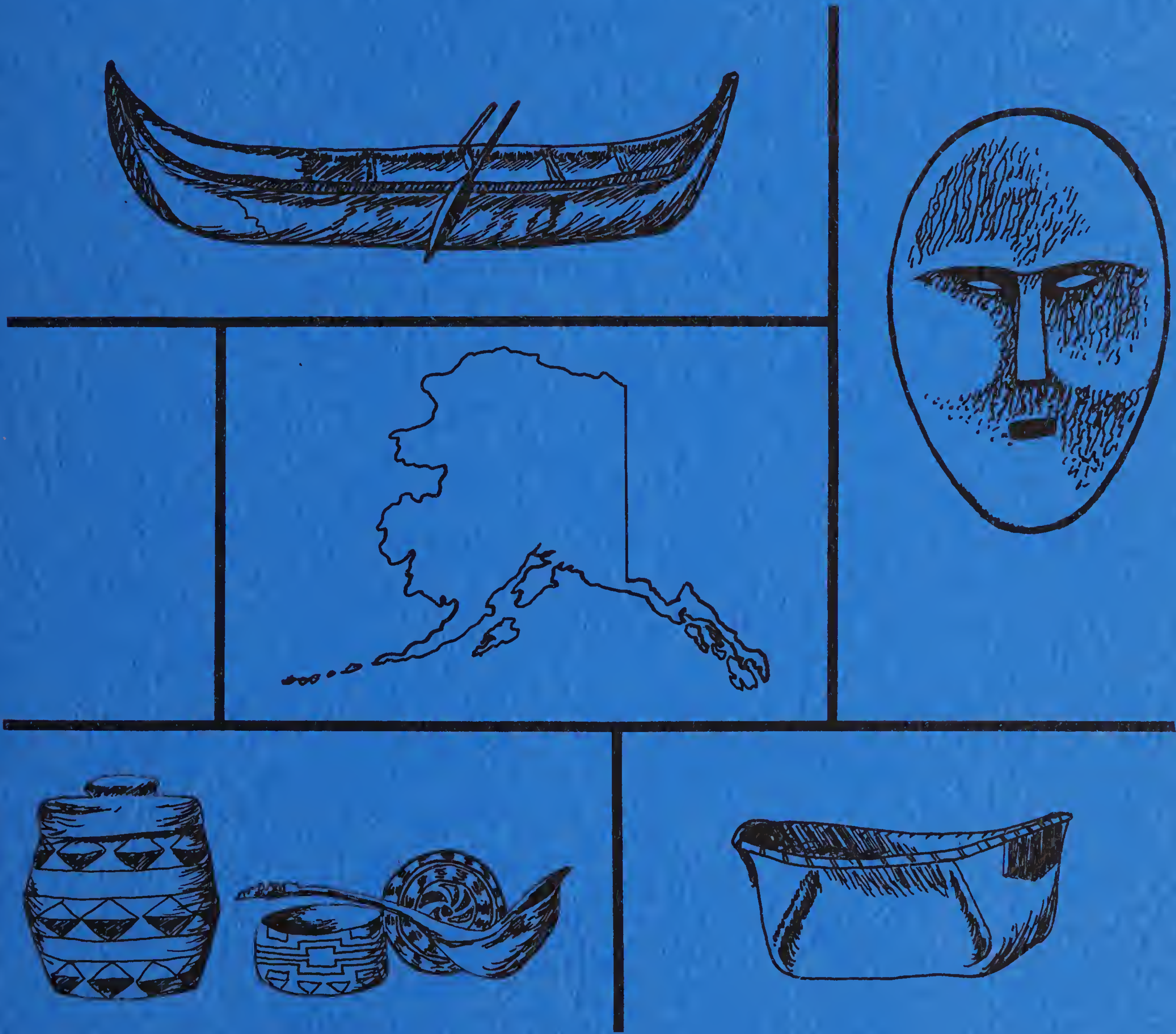
Archaeological Probability Modeling



A Report Prepared by

E. James Dixon, Jr.
Curator of Archaeology
University of Alaska Museum

for the

Bureau of Land Management, Anchorage District

NEWS RELEASE

BUREAU OF LAND MANAGEMENT – ALASKA
DEPARTMENT OF THE INTERIOR

U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

FOR ADDITIONAL INFORMATION CONTACT:

Chief, Public Affairs
Bureau of Land Management
555 Cordova Street
Anchorage, Alaska 99501

Lou Waller
Anchorage District Office
4700 East 72nd Avenue
Anchorage, Alaska 99507

This study is the result of a need to efficiently allocate BLM's (Alaska) portion of archeological field survey money. With 300 million acres of land which has only been minimally studied for presence of cultural values, we felt a very real need to obtain maximum utilization (in terms of cultural values) of each dollar spent on field surveys, as these values may relate to the on-going administration of the national resource lands.

After talking with several archeologists familiar with Alaskan archeology, it became apparent that archeologists subjectively use certain combinations of environmental factors to evaluate the probability of finding archeological values. Through this contract we have taken the initial step toward quantification of the probability of cultural site occurrence. Future follow-up studies are planned to hopefully reach the level of predictability ultimately needed for proper management and administration for the public benefit.

This report is being sent to you for your consideration. Hopefully, the report will generate some new ideas and further advance our ability to effectively manage the national resource lands.

FINAL REPORT

ARCHEOLOGICAL PROBABILITY MODELING

Submitted to

Bureau of Land Management

Anchorage District Office

(Contract #52500-CT4-114)

Submitted by

E. James Dixon, Jr.

Curator of Archaeology

University Museum

University of Alaska

Fairbanks, Alaska 99701

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This report was produced under the direction of Dr. Louis Waller, recreation planner, Anchorage District Office and Gary Matlock, Alaska State Office archaeologist.

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Bureau of Land Management

4700 East Avenue

Anchorage, Alaska 99507

INTRODUCTION

The study to develop a computer model with the capability of predicting probable concentration location for archaeological sites within the State of Alaska was begun in the late spring of 1975 under Contract #52500-CT4-114. To this end, data processing personnel from the Geophysical Institute of the University of Alaska's Fairbanks campus were contracted to aid the University Museum in the generation of a computer program which would permit the plotting of the distribution of approximately 4,000 archaeological sites in relationship to the major ecosystems of Alaska as defined in the Major Ecosystems of Alaska map prepared by the Joint Federal State Land Use Planning Commission for Alaska, 1973.

The hypothesis had been advanced (Dixon 1975) that archaeological site distribuations are not random, and that the majority of Alaskan archaeological sites are located within ecotones. Ecotones are here defined as those regions bordering two or more ecosystems. This presentation represents the results of this test and provides suggestions for a program to establish priority areas in the Bureau of Land Management Anchorage District for further survey based on probability of site occurrence and future program direction.

METHODS

A rather cumbersome method of producing the plot tapes was necessary because it proved impossible to obtain map projection data for the Major Ecosystems of Alaska map (U.S.G.S. Series E). Several federal agencies were contacted in hopes of obtaining this projection data, until finally, the Chief of the Rocky Mountain Mapping Center, Division of the U.S. Geological Survey, U.S. Department of the Interior, Mr. A. E. Letey, replied: "In all candor, we are not too sure how the 1954 Alaska map E projection originated. . . no record exists to fully explain its construction." Consequently, the following cumbersome and time-consuming method was essential in producing the archaeological site distribution overlay.

A ten inch roll of graph paper was superimposed on the Major Ecosystems of Alaska map (baseline Series E). From this superimposition, the longitude and latitude of specific points on the ecosystems map was correlated with the x-y coordinates on the graph paper. This information was transferred to coding sheets. This was done for approximately 40 points and, subsequently, cards containing this data were keypunched. A computer program was written to execute least squares polynomial fit to the third degree in order to correlate the map projection with precise site locations. The output was a set of correlations which could transform latitude and longitude to the x and y

inches for the transparent overlay. An IBM 360/40 was used to produce the plot tape, which was read by the NOVA 820. The NOVA read the 360/40 and drove the Calcomp 10" drum plotter.

The archeological site data was secured from the Alaska State Division of Parks on magnetic tape, which was brought to the Unversity by the Pricipal Investigator from the State Highways Division in Anchorage where the State Parks inventory was housed. Although the University provided the blank tape, the data was duplicated through the courtesy of the State Division of Highways. The resultant product can be seen in Figure 1, which is a photograph of the overlay on the Major Ecosystems of Alaska map. Visually, a striking positive correlation between the location of the State's major ecotones and the site locations is apparent.

The overlay plot had to be adapted to the map in such a manner that it would accurately locate the archeological sites. Longitude is depicted in the Series E map as a series of straight lines connecting latitude, however, these are in reality curved lines. This fact presents extreme difficulty in accurate plotting. It can be noted in Figure 1 that the degree of error in the plots increases northward and southward from the central strip, essentially latitude 64^{o}o and 66^{o} north. Given the limited funding for such an undertaking, the preceding methods seemed to be the most applicable in terms of producing results with in the monetary restraints.

As stated previously, the execution of this research utilized two independent data sources: The Alaska Heritage Resource Survey Date File and the Major Ecosystems of Alaska map. It was understood that the quality of data contained in both sources could not be 100 percent accurate. Errors were noted in the Alaska Heritage Resource Index, for it is difficult to precisely locate all archaeological sites in terms of latitude and longitude. The Major Ecosystems of Alaska map represents a generalized reproduction of more detailed vegetation maps and consequently, accuracy is reduced when the data becomes this generalized. For example, ecotones, those areas bordering two or more biomes, are in reality zones of transition between biomes. However, on the Major Ecosystems map, it is necessary to depict the ecotones as a solid line of contact between the ecosystems. In reality, these are very broad zones of transition between one biotic community and another. Hence, it would not be realistic to expect the quality of both these independent data sources to be such precision that plotted sites would fall directly on the ecotone lines in all cases.

The Calcomp plotter produces an "X" which possesses cross lines which are 1/8" long. When this distance is correlated with the scale of the Major Ecosystems of Alaska map, the length of the "X" equals 2.50 miles. The distance of any one of the cross lines in the "X' from the center of the "X" is, consequently, half that distance, or 1.25 miles. It was felt that the distance of 1.25 miles was a reasonable margin of error considering the limitations of the independent data sources.

Consequently, if any part of the "X" produced by the Calcomp plotter touched an ecotone line, the site was tabulated as falling within the ecotone. In other words, any site tabulated as being within the ecotone could be no more than 1.25 miles away from the line of contact between ecosystems as depicted on the Major Ecosystems of Alaska map. Using this method, a comparatively high degree of accuracy was achieved. The total number of sites plotted was 4,028. Thirty-three of this number were found to plot in the ocean and were not applicable for this study. These sites either represent shipwrecks or errors in the Alaska Heritage Resource Survey File.

Table 1: ECOTONE/NON-ECOTONE SITE FREQUENCY

QUADRANGLE	# SITES	ONE ECOSYSTEM	ECOTONE
Adak	78	0	78
Afognak	52	0	52
Amutka	8	0	8
Ambler River	27	5	22
Anchorage	52	2	50
Arctic	54	1	53
Atka	31	0	31
Attu	39	0	39
Barrow	14	0	14
Bendeleben	27	6	21
Bettles	39	6	33
Black	4	0	4
Black River	1	0	1
Barter Island	1	0	1
Bethel	11	2	9
Beaver	6	2	4
Candle	23	4	19
Chignik	8	0	8
Chandalar	4	0	4
Charley River	6	0	6
Circle	16	0	16

QUADRANGLE	# SITES	ONE ECOSYSTEM	ECTONE
Coleen	1	1	0
Cordova	97 - two sites plot in ocean	1	94
Craig	58	0	58
Christian	5	2	3
Delong	117	3	114
Dillingham	25	4	21
Dixon Entrance	21	0	21
Eagle	49	9	40
Fairbanks	55	12	43
Fort Yukon	2	0	2
Goodnews	25	6	19
Gulkana	70	19	51
Harrison Bay	1	0	1
Healy	28	3	25
Hughes	9	1	8
Iditraod	16	3	13
Ikpikpuk River	2	0	2
Iliamna	40	0	40
Juneau	73	2	71
Kaguyak	13	0	13
Karluk	32	0	32
Kateel River	5	1	4
Kenai	47	9	38

QUADRANGLE	# SITES	ONE ECOSYSTEM	ECOTONE
Ketchikan	30	0	30
Killik River	8	2	6
Kiska	7	0	7
Kodiak	207	0	207
Kotzebue	20	1	19
Kwiguk	20	4	16
Limehills	1	0	1
Livengood	29	7	22
Marshall	35	13	22
McGrath	2	0	2
Medfra	8	0	8
Misheguk Mtn.	114	5	109
Meloztna	7	4	3
Mt. McKinley	10	6	4
Nabesna	12	5	7
Naknek	13	0	13
Noatak	60	2	58
Norton Bay	30	5	25
Nome	30	6	24
Nulato	11	1	10
Ophir	12	8	4
Petersburg	64	0	64
Philip Smith Mtns.	74	4	70
Rat Islands	1	0	1

QUADRANGLE	# SITES	ONE ECOSYSTEM	ECOTONE
Ruby	5	2	3
Russian Mission	20	0	20
Sagvanirktok	6	1	5
Samalga Island	22	0	22
Seguam	10	0	10
Seldovia	76	0	76
Seward	104	3	101
Shishmaref	11	0	11
Shungnak	8	4	4
Sitka	101 - two sites plot in ocean	0	99
Skagway	29	0	29
Selawik	37	4	33
Sleetmute	64	1	63
St. Micheal	13 - one site plots in ocean	1	11
Solomon	70 - four sites plots in ocean	8	58
Sumdum	14 - one site plots in ocean	0	13
Sutwik	5	0	5
Table Mtn.	10	3	7
Talkeetna	10	1	9
Tanana	15	4	11
Taylor Mtns.	1	0	1
Teller	53	4	49

QUADRANGLE	# SITE	ONE ECOSYSTEM	ECOTONE
Teshekpuk	1	1	0
Talkeetna Mtns.	3	0	3
Tanacross	2	0	2
Tyonek	23	0	23
Ugashik	7	0	7
Unalakleet	20	2	18
Umnak	12	0	12
Unimak	50	0	50
Unalaska	108 - seven sites plot in ocean	0	101
Valdez	83	4	79
Wainwright	7	0	7
Wiseman	10	6	4
Bradfield Canal	5	0	5
Big Delta	37	5	32
Bering Glacier	1	0	1
Baird Inlet	78	28	50
Baird Mtns.	44	0	44
Beechy Point	6	0	6
Blying Sound	3	0	3
Cape Mendenhall	24	0	24
Demarcation Point	4	0	4
Flaxman Island	2	0	2

QUADRANGLE	# SITES	ONE ECOSYSTEM	ECOTONE
False Pass	19	0	19
Cold Bay	19	0	19
Gareloi Isalnd	7 - six sites plot in ocean	0	1
Hooper Bay	29	15	14
Holy Cross	14	2	12
Hagemeister Island	13	0	13
Howard Pass	43	1	42
Icy Bay	2	0	2
Kuskokwim Bay	6	2	4
Kantishna River	9	2	7
Lake Clark	3	0	3
McCarthy	10	1	9
Mt. Fairweather	45	0	45
Mt. Hayes	141	11	130
Middleton Island	4 - one site plots in ocean	0	3
Mt. Katmai	49	0	49
Mt. Michaelson	3	1	2
Meade River	2	0	2
Nushagak Bay	14	0	14
Nunivak Island	30	2	28
Port Alexander	34	0	34
Point Hope	9	0	9

QUADRANGLE	# SITES		ONE ECOSYSTEM	ECOTONE
Pribilof Islands	4	- one site plots in ocean	0	3
Point Lay	52		0	52
Port Moller	13		0	13
Prince Rupert	6		0	6
Stepovok Bay	5		0	5
St. Lawrence	18		0	18
Survey Pass	39		0	39
Trinity Islands	21		0	21
Taku River	2		0	2
Utukok River	20		0	20
Yakutat	32	- eight sites plot in ocean	0	24
TOTALS	4028	33	296	3699

ANALYSIS

The usable sample was considered to be 3,995 cases. Of this total, 3,699 fell no further away than 1.25 miles from an ecotone. Two hundred ninety-six sites occured within one ecosystem and were found to be more than 1.25 miles from the ecotone. In analyzing these statistics, 92.6% of the cases fell within an ecotone as defined by the preceding criteria. 7.4% of the cases fell outside the ecotone and are presently located in a single ecosystem. With a fairly high degree of certainty, we may state that approximately 92% of Alaska's archaeological sites occur no further than 1.25 miles from ecotone as depicted in the Major Ecosystems of Alaska map.

The Alaska Heritage Resource Index is a compilation of sites which is somewhat random, for it has listed sites which are comparatively easily documented or have been complied and listed in other sources. It represents a fairly broad inventory for the entire State. Although it is by no means complete, the sample size, 4,028 sites, is of sufficient magnitude to reduce biases which may have been introduced by this rather random data collection technique. At this time it seems reasonable to assume that futher additions to the Index will probably not greatly alter the statistics derived from the sample used for this study.

Initially it was expected that site distributions may have changed radically through time due to either 1) comparatively recent historic influences on settlement locale, or 2) major shifts in the environment through time. In an effort to evaluate the possible significance of these factors, an additional computer program was written which plotted all archaeological and historic sites which have been dated to the period following 1750 A.D. It was assumed that sites of this age were probably affected by historical influences (i.e., contact with Western European culture, either direct or indirect). Then, sites dating prior to 1750 A.D. to 1000 A.D. were plotted and plots were continued back through time prior to 1000 A.D. at 1,000 year intervals. This data indicated no significant alteration in settlement locale in the past 10,000 years. However, it cannot be overemphasized that there are large gaps in our data from the earlier time periods and in many cases the dating of these sites is not too certain. Surprisingly, changes through time, especially that period following historic contact, cannot be recognized in the ecotone settlement pattern. This may be due to the fact that early explorers, fur traders and missionaries settled in regions which were inhabited by indigenous Alaskan populations and these were ecotone locales. Also, gold rush mining activities were essentially placer operations for the most part were restricted to riverine environments where the gold had been separated from its surrounding matrix by natural agents. This would also tend to focus these types of

historic sites in ecotone settings. Nevertheless, this analysis notes a number of data gaps for which the model is not flexible. For example, the mere handful of sites dating to the period prior to 10,000 years ago is so meager that it is presently impossible to delineate Pleistocene (Ice Age) settlement patterns. In short, the model does have temporal limitations. However, the fact that archaeologists have been unable to discover sites for this period does not decrease the efficiency of the model and it remains consistent within the limits of contemporary archaeological data.

DISCUSSION OF SYSTEMEMATIC PROBABILITY SAMPLING IN ARCHAEOLOGY

Numerous papers and publications deal with various sampling techniques as they are applied to archaeology. For various approaches to this problem, see Plog (1968), Gumerman (1971, 1972), Vescelius (1960), Rootenburg (1964), Binford (1964), Ruppe (1966), Hill (1968), Longacre (1968), Redman and Watson (1070), Binford and others (1970), Mueller (1974), and Judge and others (1973). Most archaeologists would probably agree that it is impossible to record one hundred percent of the archaeological sites within any large region due to limitations in available manpower, duration of the field season and, most importantly, financial restraint. Such problems are even greater in Alaska where there is a paucity of trained personnel, where the field season is greatly reduced due to the extreme northern latitudes, and where financial restraints are even more acutely felt due to Alaska's great areal exent.

In response to these considerations, many archaeologists have attempted to implement sampling techniques which would obviate the necessity to conduct archaeological survey in every locale within a given region. Judge and others (1973:i) indicate ". . . interval transects offer the best all-around accuracy and precision for the estimation of site frequency and most site attributes." They also suggest that such transects should cross-cut ecological strata and this, in turn, may be followed by quadrat sampling within ecological strata (Ibid.). Mueller (1974) has demonstrated an analogous survey technique

which relies on transects made by survey teams of two field investigators each, cutting four swaths each across a one square mile section. The survey region was divided into environmental locales which collectively composed a much larger environment. Such techniques have proven themselves quite useful in other regions of North America and, given the environmental parameters used in this study, preliminary analysis indicates that they may be modified and applied to this situation with utility.

Finally, such a research strategy may be able to provide preliminary indications relevant to assessing the type and magnitude of the cultural resource potential of specific regions. For example, on Alaska's North Slope it is quite common for small tent ring sites to be associated along the margins of kettle lakes. Thus a moist tundra/ lake ecological setting could, in most cases, indicate this type of site occurrence. Other examples might be fish camps located near the mouth of clear water tributaries which flow into larger riverine environments. Such data would provide a valuable management tool in providing objective criteria with which to judge the magnitude and comparative importance of particular cultural resource zones.

SUGGESTED PROGRAM TO ESTABLISH PRIORITY AREA FOR THE BUREAU OF LAND MANAGEMENT ACHORAGE DISTRICT

Although the foregoing study demonstrates with reasonable assurance that more than 90% of Alaska's recorded archaeological sites are to be found in ecotone settings, definitive answers to site distribution and frequency can only be derived through field testing this postulated model. Armed with this knowledge, it seems reasonable that research and survey efforts should be allocated to test this study. A field design should be constructed to systematically and uniformly test both ecotone and non-ecotone regions for archaeological resources. Field testing should only be undertaken following probability modeling for both ecotone and non-ecotone regions. A study locale should be selected which (1) is crosscut by an ecotone as depicted by the Major Ecosystems of Alaska map, (2) for which there is little archaeologiacal data, (3) which will minimize logistic costs and optimize data recovery, and (4) can provide a test locale of equal proportions for a non-ecotone area.

This preliminary test suggests that top priority should be given to ecotone areas and that faunal resources within the ecotones be analyzed and weighted according to their importance to aboriginal populations. Major species under consideration are caribou, water fowl, black bear, sheep, goat, grizzly bear and moose for non-coastal areas. Although it is difficult to obtain specific data relevant to the distribution of various fish species, they may be accommodated in the proposed model by

amplifying the values for a given region if a fresh water aquatic environment is present. These variables may then be analyzed in an attempt to locate regions where their distributions overlap and particular species tend to concentrate at certain points in their annual cycles. This information may then be correlated, weighted and/or amplified by physical features such as lakes, rivers and general topography. Finally, non-biological resources such as mineral licks and raw materials attractive to the aboriginal populations (such as osidian sources) may also be entered into the model. It is hoped that refinement of this technique will delineate zones which demonstrate greater probability than surrounding areas.

Following the generation of probability factors on the foregoing variables, zonal transects should be conducted in these various regions at regularly spaced intervals. This will enable an objective and quantifiable sampling technique for large regions. Extrapolation to regions between transects which demonstrate similar probability values will then be possible. In short, the method should produce a means by which accurate statements relevant to any given region's cultural resource potential may be made. The advantages of such a technique become obvious when one considers the vast regions within Alaska to be inventoried and strict financial limitations available for such inventories.

A study locale should be selected which would optimize the archaeological survey time and minimize the expense to the Bureau. The area must also be cut by an ecotone as defined by the ecosystems map so

that probability zones may be delineated within the ecotone itself. Neighboring non-ecotone areas should also be available for equal survey effort. Logistic considerations are extremely important for, by minimizing such problems, the Bureau can maximize its data collection. Several such areas exists within the Fortymile District. Hère, the Tanana River provides a riverine ecosystem which rises to the Yukon-Tanana uplands in the north and is bounded on the south by a relatively flat spruce forest biome. This region is accessible by surface transportation and is suitable for the purpose previously oulined.

Size and composition of the field crew is dependent on funding limitations, however. Four individuals providing a minimum of two two-man teams could execute the aforementioned zonal transects. These transects should be done in a systematic fashion following modeling of the probability areas within the ecotone so that reliable and quantifiable statistical projecions regarding the total area may be drawn from the results of this survey sampling technique. Testing of these areas should not be limited to surface indications alone, by should by coupled with subsurface tests at regular intervals within the probability zones. An equal survey effort and identical survey method should be implemented in a neighboring non-ecotone region. Both study areas should be selected following probability modeling and should be of identical size.

SUMMARY

1. This study concludes that 92.6% of Alaska's cultural resources as recorded in the Alaska Heritage Resource Index occur in ecotone settings as defined by the Major Ecosystems of Alaska map.

2. This projection has temporal limitations and is, of necessity, restricted by the limits of contemporary anthropological knowledge.

3. This preliminary test indicates that it may ultimately be possible for the Bureau of Land Management to allocate its resources according to the distribution of cultural resources, i.e., 90% focused on ecotone regions. However, until demonstrable field testing confirms, rejects or modifies this initial indicator, extreme caution should be exercised in using it as a management tool.

4. An objective and quantifiable method has been suggested by which the search for cultural resources may be narrowed to specific locales within ecotone and non-ecotone regions.

5. A field survey strategy has been proposed which should follow probability modeling.

6. The proposed methods should facilitate objective and statistically quantifiable projections of cultural resource potential for any given region.

7. Such projections will be of great utility in (a) preparing environmenta impact statements, (b) attempting to plan and execute proposed archaeological salvage operations, (c) assessing contractors' estimates in a realistic fashion, and (d) increasing the speed and certainty with which the Bureau of Land Management may respond to any of the above situations.